AbstractID: 3873 Title: Limitations of the photon and electron transport algorithms in GEANT4 for radiotherapy applications

Purpose:
To examine the limitations in the photon and electron transport algorithms in GEANT4, so as to identify its suitability for radiotherapy applications.

Method and Materials:
A set of simulations were performed to access the accuracy of GEANT4. We calculated depth dose distributions of photon and electron beams incident on a water phantom, and examined the effects of dose perturbation in the presence of a lead interface. The results are compared to the EGSnrc Monte Carlo code. We attempt to provide explanations for the differences observed. An investigation of the problems in the condensed history algorithm is done through a series of cavity simulations under Fano conditions.

Results:
In homogeneous water, the depth dose distribution of a 10 MeV incident electron beam depends on the electron step size limitations and secondary particle production thresholds. The disagreement with BEAMnrc is over 4%, which is partly due to differences in cross section data among the EM models. For incident photon beams of 400 keV and 6 MeV, GEANT4 agrees with EGSnrc to within 0.4% and 2% respectively beyond the depth of dose maximum. Larger differences are found in the buildup regions due to problems in electron transport. In a Pb/water geometry, we observe an underdose of up to 84% upstream of the interface for a 100 kVp beam. This is mainly due to the neglect of spin effects in electron elastic scattering. In the Fano cavity simulations, problems in electron step and boundary crossing algorithms result in an underestimation of cavity dose by up to 39%. Accurate cavity response can be obtained using severe step size restrictions.

Conclusion:
GEANT4 is unsuitable for simulations where electron disequilibrium exists. Improvements in boundary crossing and backscattering are needed, and spin effects should be modeled.

Conflict of Interest (only if applicable):